BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

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In the Matter of	)	
	)	
Allocation of Spectrum Below	)	ET Docket No. 94-32
5 GHz Transferred from	)	
Federal Government Use	)	

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COMMENTS OF
SOUTHWESTERN BELL TELEPHONE COMPANY

SOUTHWESTERN BELL TELEPHONE COMPANY

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ET Docket No. 94-32

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Table of Contents

SUMMARY*

Southwestern Bell Telephone Company (SWBT) submits these Comments in response to the Commission's NPRM seeking comment on potential applications for 50 MHz of spectrum that is to be transferred from the Federal Government to the private sector. The Commission seeks by the reallocation to provide for the introduction of new services and the enhancement of existing services.

In these Comments, SWBT recommends that the Commission's public interest goals would best be served by allocating one of the three bands identified for immediate reallocation, the 2390-2400 MHz band, exclusively for the deployment of wireless local loop technology. SWBT believes the Commission's public interest goals would further be served by pairing the 2390-2400 MHz band with the 2300-2310 MHz spectrum band. This pairing would permit a more efficient deployment of wireless local loop technology, and would result in more efficient use of both bands. SWBT's proposed use of this paired spectrum for wireless local loop would primarily be a fixed use, with the potential for ancillary mobile use.

The deployment of wireless local loop will benefit the public by reducing the cost of the telephone infrastructure while providing the capability to offer new services. Wireless local loop technology can reduce installation and maintenance costs, provide bandwidth on demand, and reduce the cost of providing telephone access lines to customers. Wireless local loop

* All abbreviations used herein are referenced within the text.

technology allows rehabilitation of aging plant to be accelerated because of lower costs and quicker deployment. Local exchange carriers can thus particularly improve service to customers in areas where the telephone plant is older and service quality may be beginning to deteriorate, and rehabilitation is difficult and costly.

Because of the nature of the existing amateur operations in the 2390-2400 and the 2300-2310 MHz bands, sharing of this spectrum by a wireless local loop system and amateur operators is problematic, particularly in high population density areas. SWBT thus urges that the 2390-2400 MHz band, paired with the 2300-2310 MHz band, be restricted for the exclusive use of deploying wireless local loop technology. SWBT recommends that the Commission consider allocating another spectrum band (2400-2410 MHz) for amateur use on a primary basis.

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COMMENTS OF
<u>SOUTHWESTERN BELL TELEPHONE COMPANY</u>

Southwestern Bell Telephone Company (SWBT) respectfully submits these Comments in response to the Commission's Notice of Proposed Rulemaking (NPRM) herein released on November 8, 1994.[1] In the NPRM, the Commission seeks comments on potential applications for 50 megahertz (MHz) of radio spectrum that is to be transferred to the private sector as required by the Omnibus Budget Reconciliation Act of 1993 (OBRA). Pursuant to OBRA, the spectrum identified for immediate reallocation consists of 50 MHz at the 2390-2400 MHz, 2402-2417 MHz, and 4660-4685 MHz spectrum bands.

The Commission's stated objective in reallocating this spectrum is to ensure that the spectrum is put to its best and most valued use and that the greatest benefit to the public is attained.[2] SWBT believes that the Commission's goals would best be met by allocating one of the spectrum bands available in this proceeding (2390-2400 MHz) exclusively for deployment of wireless local loop (WLL) technology, a fixed service with potential for

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[1] <u>In the Matter of Allocation of Spectrum Below 5 GHz Transferred from Federal Government Use</u>, ET Docket No. 94-32, <u>Notice of Proposed Rulemaking</u> (released November 8, 1994) (NPRM).

[2] <u>NPRM</u> at ¶ 8.

some ancillary mobile applications. SWBT further believes that the public interest would best be served and WLL technology could most efficiently be deployed by pairing the 2390-2400 MHz band with the available 2300-2310 MHz spectrum band for immediate allocation.[3]

I. <u>**ALLOCATING THE 2390-2400 MHz SPECTRUM BAND PAIRED WITH THE 2300-2310 MHz SPECTRUM BAND FOR WIRELESS LOCAL LOOP WOULD RESULT IN SUBSTANTIAL PUBLIC BENEFIT**</u>.

As background, the WLL technology proposed by SWBT[4] would replace the "drop wire," as well as a portion of the telephone distribution plant, that presently provides service to homes and/or small businesses, with a low power microcellular radio system. SWBT's proposed use of this paired spectrum for WLL would primarily be fixed, with the potential for some ancillary mobile use. The WLL system consists of radio transceivers (radio ports), mounted on existing structures such as telephone poles, utility poles, and street lights, throughout a residential neighborhood to provide connectivity to transceivers mounted on customers' homes. The use of wireless technology allows customer traffic to be concentrated "in the air," resulting in far more efficient use of

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[3] The 2300-2310 MHz band is currently scheduled to be made available to the private sector in January 1996. Advancing that date, however, could accelerate the most efficient deployment of wireless local loop service. See Section III, <u>infra</u>. In addition, the Commission has urged making the 2300-2310 MHz spectrum band available for immediate allocation. <u>See</u> <u>In the Matter of Report to Ronald H. Brown, Secretary, U.S. Department of Commerce Regarding the Preliminary Spectrum Reallocation Report</u>, FCC 94-213, ¶ 51 (released August 9, 1994).

[4] SWBT's proposed WLL technology is based on "Generic Criteria for Version 0.1 Wireless Access Communications Systems (WACS)," Bellcore Technical Reference, TR-INS-001313, Issue 1, October 1993, and "Generic Criteria for Version 0.1 Wireless Access Communications Systems ("WACS")," Bellcore Technical Reference TR-INS-001313, Supplement 1, June 1994.

the telephone feeder and distribution network through the use of shared resources. Another significant benefit of WLL technology is that it is digital, and is fully encrypted to allow private and secure communications.

Each radio port will serve an area covered by a circle with an approximate radius of 1,000 feet, which will allow each port to serve approximately 35-40 homes. The low antenna heights and low power, with attendant frequency reuse, lead to very high capacity and spectral use efficiency. The use of bandwidth on demand and digital transmission also allows flexible use of the system, as well as advanced innovative applications arising from wireless access to the public switched telephone network (PSTN), such as remote meter reading and rapid recovery systems for natural disasters. These significant network efficiencies and public benefits are not limited to deployment of WLL technology in densely populated urban areas, however. In less densely populated areas, the radio ports can be mounted higher than at conventional elevation, permitting a single radio port to efficiently serve an even greater number of customers.

SWBT's primary use of WLL will be to provide new access lines and to rehabilitate aging plant. Another significant public benefit of WLL technology is that it will permit easier and less expensive rehabilitation and replacement of aging copper plant, with fewer accidental service disruptions and less inconvenience to customers. For example, it would no longer be necessary for the telephone company to dig through established yards and streets in order to rehabilitate facilities. As a result, deployment of WLL technology will allow local exchange service providers to accelerate the rehabilitation of aging plant. Utilizing WLL, local exchange carriers can thus particularly improve service to customers in areas where the telephone plant is older and service quality is beginning to deteriorate, and where rehabilitation is difficult and costly.

In summary, the Commission should allocate the 2390-2400 MHz spectrum band, paired with the 2300-2310 MHz spectrum band, for the exclusive purpose of deploying wireless local loop. As explained above, allocating this paired spectrum to wireless local loop will result in substantial public benefit, including providing new and enhancing existing telephone service, reducing the cost of maintaining and replacing telephony infrastructure, and offering the capability to provide advanced new services.

II. ALLOCATING THE 2390-2400 MHz SPECTRUM BAND FOR WIRELESS LOCAL LOOP, AND PAIRING IT WITH THE 2300-2310 MHz SPECTRUM BAND, WILL FACILITATE EXTENSIVE DEPLOYMENT OF ADVANCED TECHNOLOGY.

For some time, SWBT has been investigating the use of wireless technology in the local loop for residential and small business telephone service. On June 19, 1992 the Commission granted SWBT's technology affiliate, Southwestern Bell Technology Resources, Inc., an experimental license to test WLL technology in St. Louis, Missouri. Nine quarterly progress reports have been filed relating to this trial, and a tenth quarterly progress report will be filed December 19, 1994.[5] SWBT anticipates that the results of this trial will indicate that WLL technology is competitive both in price and in level of service when compared to

[5] See File # 3037-EX-PL-92 (Quarterly Progress Reports of Southwestern Bell Technology Resources, Inc.).

copper wire and fiber digital loop carrier technology. Before effective deployment of this advanced technology can occur, however, spectrum must be allocated specifically for use with this technology. SWBT's analyses have shown that WLL technology can be effectively deployed with 20 MHz of spectrum.

One of the spectrum bands available for allocation in this proceeding, (4660-4685 MHz), is above 3 GHz. Because of economics and radio frequency propagation characteristics, SWBT believes that spectrum appropriate for WLL should be below 3 GHz. In addition, equipment necessary to utilize the 4660-4685 MHz spectrum band for WLL is more costly because more equipment is currently produced for lower frequencies and because higher cost circuitry is required for the higher frequencies. Finally, because most of the radio links for the wireless local loop application will not be line-of-sight, use of frequencies in the 4.6 GHz band would present difficult coverage and service problems. Based on these factors, SWBT believes that the 4660-4685 MHz spectrum band would be inappropriate for use with WLL.

The two other frequency bands which are the subject of this proceeding, 2390-2400 MHz and 2402-2417 MHz, have appropriate propagation characteristics for use with WLL technology. The existing use, however, of the 2402-2417 MHz band for industrial, scientific, and medical (ISM) applications make use of this band for WLL problematic. The most prevalent use of this spectrum is for microwave ovens, which would likely cause unacceptable interference with residential WLL service. In addition, the WLL system could cause unacceptable interference with other ISM applications operating in this band. Thus, the 2402-2417 MHz band would also appear to be inappropriate for use with WLL technology.

The remaining spectrum band available for allocation in this proceeding, 2390-2400 MHz, is most appropriate for deployment of WLL technology. It is, however, "unpaired," thus necessitating the use of Time Division Duplex ("TDD") technology. The TDD technology presents a number of disadvantages in an outdoor environment, including greater sensitivity to delay spread, inefficient use of radio resources, and wide area synchronization requirements. Consistent with the Commission's NPRM herein,[6] SWBT thus recommends that the 2390-2400 MHz spectrum band available for allocation in this proceeding be paired with the available 2300-2310 MHz spectrum band, and that the combined spectrum provided by these paired bands be allocated exclusively for WLL deployment.[7] By allocating this paired frequency to WLL, the Commission would enable the use of Frequency Division Duplex (FDD) technology with WLL, which would result in a much more efficient WLL system.[8] In addition, the proximity of these paired bands to the Emerging Technologies frequency band, along with the fact that emerging technologies commonly use FDD technology, would most likely keep the cost of equipment necessary for deployment of WLL lower.

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[6] NPRM at ¶ 17.

[7] Allocating the 2390-2340 MHz band and the 2300-2310 MHz band exclusively for WLL deployment is consistent with Commission policy for other wireless services, including cellular, paging and PCS.

[8] For a detailed analysis and comparison of TDD technology and FDD technology, see Appendix A attached hereto, which is an excerpt from D. Duet, J.F. Kaing, D.R. Wolter, "An Assessment of Alternate Wireless Access Technology for PCS Applications," IEEE Journal of Selected Areas of Communications, August, 1993,Vol. II, No. 6 at pp. 861-869 (© Copyright 1993 IEEE).

SWBT recognizes the value of amateur radio users currently operating in the 2390-2400 MHz band. Based on its continuing and further analyses, SWBT believes that it would be problematic for the paired 2390-2400 MHz and 2300-2310 MHz spectrum bands to be shared by amateur users and WLL on a "co-primary" basis without the potential for such shared use to cause unacceptable co-channel and adjacent channel interference to one of the services, particularly where amateur use and WLL systems are in close proximity to each other. Therefore, SWBT recommends the Commission allocate the entire 2300-2310 MHz band and the 2390-2400 MHz band exclusively for WLL and, to accommodate the spectrum needs of amateur radio users, allocate the 2400-2410 MHz band for the exclusive use of amateur radio users. This allocation to amateurs would be consistent with the reported widespread existing use by amateurs of the 2400-2402 MHz band for amateur satellite operations,[9] and the reported planned expanded use of the 2400-2410 MHz band for future generation amateur satellite operations.[10]

As an alternative approach, SWBT suggests that the amateur radio users be allowed to use the 2303.5-2304.5 MHz band and the 2393.5-2394.5 MHz band on a secondary basis while allowing WLL to use this spectrum on a primary basis. This approach would allow the amateur radio users to continue to operate as they do today (as secondary users), while providing necessary interference protection to the WLL application (as the primary user) pursuant to

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[9] See "AMSAT News," The AMSAT Journal, May/June 1994, p. 30; "Current Amateur Satellite Frequencies," The AMSAT Journal, July/August 1994, p. 12.

[10] See "The Microwave Links of P3D," The AMSAT Journal, May/June 1994, pp. 25-26.

the Commission's rules. Additionally, under this approach, the Commission could also allocate the 2400-2410 MHz band exclusively for amateur radio users, if necessary.

SWBT would prefer WLL be given exclusive use of the 2300-2310 MHz band and the 2390-2400 MHz band and believes such use would allow a more reliable and cost effective service to be offered to the customer. If some other approach is believed necessary, SWBT offers an alternative that will adequately meet the needs of the amateur radio users while providing sufficient spectrum and protection for the WLL service.

Finally, deployment of advanced WLL technology is simply not facilitated by existing spectrum allocations. In particular, the revised build-out requirements for the 10 MHz and 30 MHz Personal Communications Service (PCS) licenses, although reduced, remain too stringent to allow SWBT to consider using this spectrum solely for WLL service. As described above, SWBT's primary use of WLL would be to satisfy the demand for new access lines and for rehabilitation of aging plant. Together, SWBT anticipates that these uses would produce roughly three percent coverage of a particular service area per year. In addition, SWBT believes it would be preferable to use spectrum in a single band (the 2.3 GHz band) as opposed to possibly being required to use spectrum in two separate bands (the 1.8/1.9 GHz PCS spectrum and the 2.3 GHz spectrum) for WLL service. Using spectrum in a single band would be more efficient and would eliminate the necessity for SWBT to develop two separate wireless local loop systems to support two different spectrum bands. Finally, PCS licensees will be required to provide primarily a mobile service. Since WLL would be primarily a fixed service, with only ancillary potential for mobile use, it does not appear that WLL would satisfy the mobility requirement of PCS, and thus PCS spectrum would be inappropriate for WLL deployment.

III. SWBT's PROPOSED ALLOCATION OF THE 2390-2400 MHz BAND PAIRED WITH THE 2300-2310 MHz BAND TO DEPLOY WIRELESS LOCAL LOOP WOULD RESULT IN GREATER PUBLIC BENEFIT THAN OTHER SUGGESTED USES OF THE SPECTRUM.

In the NOI stage of this proceeding, several parties suggested various service offerings for the spectrum available for reallocation in this proceeding. SWBT believes that its proposal for the 2390-2400 MHz spectrum band, paired with the 2300-2310 MHz spectrum band, for the deployment of WLL technology would clearly result in the greatest public benefit.

As an initial matter, SWBT suggests that the allocation of spectrum in channel blocks of one or two megahertz is not appropriate for this spectrum, and certainly not appropriate for wireless local loop deployment. Due to the quality of service and frequency reuse requirements, as well as the high capacity required for wireless local loop service, SWBT believes the public interest would best be served by allocating the paired 2300-2310 MHz and 2390-2400 MHz bands as a single spectrum block. Were the spectrum to be fragmented into small blocks, the areas where wireless local loop could be deployed may be restricted due to very localized uses of small pieces of the spectrum. This would result in lower overall efficiency in the use of spectrum.

In-Flight Phone Corporation ("IFPC") has proposed that the Commission allocate the 2390-2400 MHz spectrum band for an aeronautical audio/visual service. SWBT questions whether IFPC's proposed service would serve the broad public interest, particularly with respect to the typical short-duration flight. Furthermore, most aircraft are not equipped to deliver this entertainment, and if they were, taped entertainment would work as well. Finally, the air passenger who needs "real time" information for business or travel purposes could satisfy this need with existing air-to-ground telephony. In short, IFPC's proposed service would only benefit a relatively small portion of the population, using valuable spectrum resources. SWBT's wireless local loop application has the potential to benefit a much more significant percentage of society and can also help provide telephone service more efficiently to those who do not have it today.

Loral/Qualcomm proposes that the 2390-2400 MHz and 2402-2417 MHz bands be allocated for Mobile Satellite Service (MSS) uplinks. American Mobile Satellite Corporation (AMSC), however, which also has interest in MSS services suggests that these bands would not be suitable for providing MSS uplinks due to interference from ISM devices and Part 15 devices currently operating in this spectral region. Given the previous Comments, there appears to be some doubt whether these frequencies are technically suitable for MSS. There is no doubt, however, that the 2390-2400 MHz spectrum band (paired with 2300-2310 MHz) is highly suitable for wireless local loop deployment.

Finally, SWBT agrees with the Commission that competitive bidding on a Basic Trading Area (BTA) basis may be appropriate for the paired 2390-2400 MHz and 2300-2310 MHz spectrum bands. This would allow the Commission to take advantage of its familiarity with these license areas and the software necessary to administer the necessary auctions. In addition, the telecommunications industry is familiar with the BTA license areas. SWBT cautions, however, that licensing what is essentially a local loop technology on a BTA basis gives rise to a unique situation. In most BTA markets, there is often more than one local exchange company providing franchised local exchange service within the BTA. For example, in the Houston, Texas BTA, several local exchange companies (including Fort Bend, GTE, Lufkin-Conroe, Sugarland, SWBT, United/Centel) provide local exchange service within their respective franchise service areas. To accommodate this situation, SWBT suggests the Commission allow a license partitioning system for the BTA service area, somewhat similar to the partitioning system the Commission has allowed for rural telephone companies offering broadband PCS.[11] Allowing the partitioning of wireless local loop spectrum through an entire BTA (and not limited to rural areas) would: (1) enable the wireless local loop provider to essentially match its spectrum license with its franchised service territory, (2) avoid wasteful allocation of spectrum to a carrier that is not authorized to provide service in the entire BTA, (3) help assure that all the spectrum allocated to the BTA for wireless local loop purposes would be utilized throughout the BTA, as opposed to only a portion of the spectrum being used by a single provider in its franchised service area, and (4) help bring the

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[11] In the Matter of Implementation of Section 309(j) of the Communications Act - Competitive Bidding, PP Docket No. 93-253, Fifth Report and Order, ¶¶ 149-151 (released July 15, 1994).

benefits of wireless local loop technology to a wider range of customers.

IV. CONCLUSION

As demonstrated herein, SWBT's proposal to allocate the 2390-2400 MHz spectrum band, paired with 2300-2310 MHz spectrum band for the exclusive use of wireless local loop, would result in the greatest public benefit for this spectrum. SWBT therefore recommends that the Commission allocate the paired 2390-2400 MHz and 2300-2310 MHz spectrum bands for the exclusive use of wireless local loop deployment.

Respectfully submitted,

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Appendix A
FDD vs TDD Technology in Outdoor Applications

This section provides an assessment of the relative strengths and weaknesses of Frequency Division Duplex (FDD) and Time Division Duplex (TDD) as they apply to spectrum considerations, radio design considerations, and radio implementation considerations for an outdoor radio communications system.

Spectrum Considerations: The amount of spectrum required for both FDD and TDD is similar. The difference lies in the fact that FDD employs two bands of spectrum separated by a certain minimum bandwidth (guard band), while TDD requires only one band of frequencies. In the allocation process for the deployment of a radio service, TDD's strength lies in the fact that it may be easier to find a single band of unassigned frequencies than it would be to find two bands of unassigned frequencies separated by the required bandwidth. The amount of unassigned spectrum in the U.S. for public radio services is very small and generally not in paired groups. For services requiring small amounts of unassigned spectrum such as wireless public phones, a TDD system would best use this spectrum. This apparent strength of TDD only applies to radio services requiring a small amount of spectrum in a single band. The current docket provides access to spectrum which can be readily allocated on a paired basis. The only spctrum blocks amenable to such pairing are the 2300-2310 MHz and 2390-2400 MHz blocks. The other blocks would result in too much band separation.

Radio Design Considerations: Fundamental limitations on the design parameters of an outdoor radio system result from the effects of the radio propagation environment. Radio-wave scatterers create multiple signals that arrive at the receiving antenna displaced with respect to each other in time and space, and result in a smearing of the pulse. This smearing is called time delay spread and, without countermeasures (equalization), it causes intersymbol interference and controls the upper limit of the transmission rate through the radio channel.

The implication of Radio Frequency (RF) channel symbol rate on the selection of a duplex method depends to some degree on the system requirements. If the design of a radio system calls for a RF channel symbol rate that is high enough to be limited by the time delay spread of the propagation environment, an FDD system can accommodate twice the symbol rate, and thus twice as many users per port transceiver, as a TDD system. This is due to the fact that the channel symbol rate of a port transceiver in an FDD system on one of its frequencies is one-half that of a TDD system. Thus, FDD systems, because they use two frequencies, can accommodate twice the one-way TDD symbol rate on each frequency.

If the design of a radio system calls for a RF channel symbol rate that is not limited by the time delay spread of the propagation environment, the number of users per port transceiver would be the same. This would be accomplished in a TDD system by doubling the symbol rate on each port transceiver. However, the equalization complexity (if equalizers are required) would be more complex for the TDD system, and the peak power requirement would be twice that of the FDD system. In an outdoor wireless local loop environment, delay spread is a significant factor.[A1]

In addition to pulse smearing, multipath interference causes the input signal strength to the receiver to vary widely in amplitude. This variability can be conveniently mitigated to a great extent by employing either spaced or cross-polarized antenna diversity. For a given frequency, the transmission loss of a radio channel is reciprocal. This means that a TDD system benefits from higher-order antenna diversity without the need for multiple antennas at the portable set. This benefit can be exploited in a TDMA system by having the port transceiver select the best signal (selection diversity) from its antennas when receiving a specific signal from the subscriber unit; then when the port next transmits to that subscriber unit, it uses the same antenna. This scheme, however, works only when a two-way link has been established. It does not provide diversity for the units which are monitoring channels for

[A1] As an example, see the Ninth Quarterly Progress Report to the FCC on experimental license, file number 3037-EX-PL-92, call sign KM2XBI, filed 19 September, 1994.

signal strength and Carrier-To-Interference Ratio (C/I) prior to call setup or link transfer, or when the portables are listening for alerting messages. In addition, the performance of most high capacity radio systems will be interference limited. The amount of interference at the radio port may be different than that at the subscriber units. Therefore, the channel is reciprocal in transmission loss, but not in C/I. This can also cause problems in either approach and argues for the use of two antennas in the subscriber unit of a TDD system as well as in the FDD case.

Another antenna related design consideration when selecting a duplex scheme is whether a duplexer is required in the port transceivers and subscriber units. A duplexer adds weight, size, and cost to a radio transceiver, and can place a limit on the minimum size. TDD is a burst mode scheme. During the transmit burst of TDD, the receiver is switched out. TDD, therefore, does not require a duplexer. Although duplexers are used on most FDD systems, they are not required in subscriber units of FDD systems employing Time Division Multiple Access (TDMA). With TDMA systems, the transmit time slot and the receive time slot of the subscriber unit can occur at different times. With the use of a simple RF switch in the unit, the antenna can be connected to the transmitter when a transmit burst is required and to the receiver for the incoming signal. The RF switch thus performs the function of the duplexer, but is less complex, smaller in size, and less costly.

Radio Implementation Considerations: Since FDD uses different frequencies for each direction of transmission, port-to-subscriber and subscriber-to-port transmissions cannot interfere with each other even if the channel timing on the two frequencies are not synchronized. For TDD, however, this is not the case. On each TDD link, precise synchronization of the transmit and receive bursts is required. Without synchronization, it is possible for port radios operating on the same frequency to have overlapping transmit and receive bursts. Lack of synchronization in these systems will reduce overall system capacity by an extent dependent on the port/subscriber power differences and the access method used. Computer simulations[A2] comparing synchronous and asynchronous TDD and FDD portable communications systems indicate a substantial difference in the degradation of the first percentile local-mean uplink Signal-To-Interference Ratio between asynchronous FDD ports and asynchronous TDD Ports. The simulations showed that the degradation for TDD asynchronous Ports was two to five times greater than the degradation for asynchronous FDD ports. These differences were dependent on port/subscriber unit power differences (from ten to twenty dB) and the downlink access method (TDM or TDMA). The difference in degradation between asynchronous FDD and TDD ports implies a greater reduction in system capacity for TDD systems.

[A2] **J. C.-I. Chuang, "Performance limitations of TDD wireless personal communications with asynchronous radio ports," Electronic Letters, Vol. 28, No. 6, pp. 532-534, March 12, 1992.**

To reduce this degradation, precise synchronization of all radio ports and portables to within an estimated 3 to 5 microseconds is required. This is not a problem for in-building applications; however for wide-area applications, synchronization may need to be derived from the digital distribution network connecting the radio ports to a switching center. This network synchronization will add significant complexity and extra expense, especially for wide-area systems where several switching and control centers are involved.

Another radio implementation consideration when selecting a duplex scheme is transmission delay. Even with synchronized radio systems, transmission delay can affect system performance. Transmission delay can be introduced into a system by the speech coder and the implementation of any time division techniques such as Time Division Multiplex, Time Division Multiple Access or Time Division Duplex. The transmission delay caused by a time division access method is dependent on the frame length. Frame lengths in modern systems range from 2 milliseconds to 16 milliseconds. However, speech coding and access methods can be common to both duplex methods. The third possible source of transmission delay in time division schemes, however, applies to only a TDD system. This delay is caused by the length of the TDD frame which includes both the transmit and receive bursts. Each transmit burst is followed by a receive burst, and therefore this separation adds delay into the transmission path. The amount of delay will depend on the number of time slots and overhead bits in a frame. Delay caused by a time duplex method can constrain the implementation of a system if the delay requirements are stringent.

A third implementation consideration is that of equipment utilization. In a heavily loaded radio system which is efficiently designed and traffic engineered to operate at the maximum bit rate dictated by the delay spread environment, each TDD port transceiver effectively sits idle half the time. Therefore for a given amount of traffic, a TDD system will require twice as many port transceivers as an FDD system, significantly increasing cost.

Table A.1 summarizes the strengths and weaknesses of each duplex method. For a limited area service such as private residential or in-building applications, TDD has the advantage of spectrum flexibility and a simplified handset antenna diversity implementation. On the other hand for an outdoor, wide-area service, TDD introduces problems with the need for wide-area synchronization and a less efficient use of the port radios in a delay spread limited environment. For a radio service operating in a delay spread-limited propagation environment as envisioned for wireless local loop, a system employing FDD better matches the propagation environment and the needs of the service provider.

Criteria	FDD	TDD
Spectrum Considerations		
Amount of Spectrum	Similar	Similar
Spectrum Needs	Paired bands, requires frequency separation.	Single or multiple bands.
Design Considerations		
Delay Spread Limited Environment		
Channel symbol rate	2 channels, n bits/sec trans., n bits/sec rec.	1 channel trans. and rec. alternately n bits/sec
Max. number of users per port transceiver	Double that of TDD	Half that of FDD
Equalizer complexity	Same	Same
Peak Power	Same	Same
Delay Spread Not Limiting		
Channel symbol rate	2 channels, n bits/sec trans., n bits/sec rec.	1 channel trans. and rec. alternately, 2n bits/sec
Max. number of users per port transceiver	Same	Same
Equalizer complexity	Less complex, if required	More complex, if required
Peak Power	Half that of TDD	Double that of FDD
Antenna diversity required	Port - yes Subscriber unit - yes	Port - yes Subscriber unit - not rqd, but desirable
Duplexer required	Port - yes Subscriber unit - yes except for TDMA	Port - no Subscriber unit - no
RF filters	Two filters each half of total RF bandwidth	One filter for total of RF bandwidth

Continued on next page

Implementation Considerations		
Synchronization between co-channel ports	No	Yes - for wide area systems
Transmission delay due to duplex method	No	Yes
Port equipment utilization	Twice TDD	Half of FDD

Table A.1 - Comparison of FDD and TDD (continued)